Space Weather Technical Forecast

Issued on Friday, 24 February 2023 at 12:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: M-class flares (R1-R2/Minor-Moderate radio blackouts) likely throughout. Chance of G1/Minor Storm Days 3 and 4 (26-27 Feb) due to coronal hole influence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low with occasional C-class flares occurring over the last 24 hours. There are now six sunspot regions on the visible disc, most with some magnetic complexity, but varying in size. AR3234 is the largest region on the disc, with a delta region in one of the intermediate spots. AR3235, whilst small, also has a small delta region and a north-south magnetic alignment which is likely to increase shear. AR3236 grew rapidly during the period. Other regions either showed some decay or were small and simple.
Currently no significant Earth-directed CMEs are forecast, although glancing impacts may occur on 25 Feb.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by DSCOVR at L1, were indicative of a High Speed Stream (HSS). The wind speed was mostly elevated, varying between 500-610 km/s, but declining recently to around 470 km/s. The density was largely at average or above average levels. The IMF was initially largely moderate, but became mostly weak from 24/0400 UTC. The north-south component, Bz, was initially weakly negative, but became mostly weakly positive from 23/2300 UTC. The phi angle was mainly away from the Sun (positive) to start, becoming negative or variable from 23/2230 UTC. Geomagnetic activity was initially Unsettled to Active (Kp 3-4), becoming mostly Quiet later in the period.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 remained at Background levels. High energy electron flux (greater than 2MeV) at GOES16 was mostly at background to moderate levels, but very briefly reached High levels of 1008 pfu at 23/1930 UTC. The associated 24-hour electron fluence has been below the Active (1e8 integrated pfu) threshold on a rising trend, reaching 1.08e7 integrated pfu at 24/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to be Moderate with a slight chance of High activity. The most likely regions to flare are AR3234 and AR3235 as both have delta spots, and perhaps also AR3236 which has developed rapidly in the last 24 hours.

Solar Wind / Geomagnetic Activity: A glancing blow from a CME is possible on 25 Feb, but most of this should pass above Earth and confidence is low. Earth is currently experiencing a HSS. There are two further coronal holes, CH78 and CH79, which are expected to influence solar winds over the next four days. Overall, it seems likely that wind speeds will be elevated or slightly elevated for much of this period, perhaps increasing to strong by Day 4 (27 Feb). Both coronal holes have negative polarity, and therefore are more favoured for a geomagnetic response now we are approaching the March equinox.
Geomagnetic activity is expected to be Quiet to Active with a risk of G1/Minor Storms due to the various HSS influences. This risk is probably highest on Days 3 and 4 (26-27 Feb) due to the

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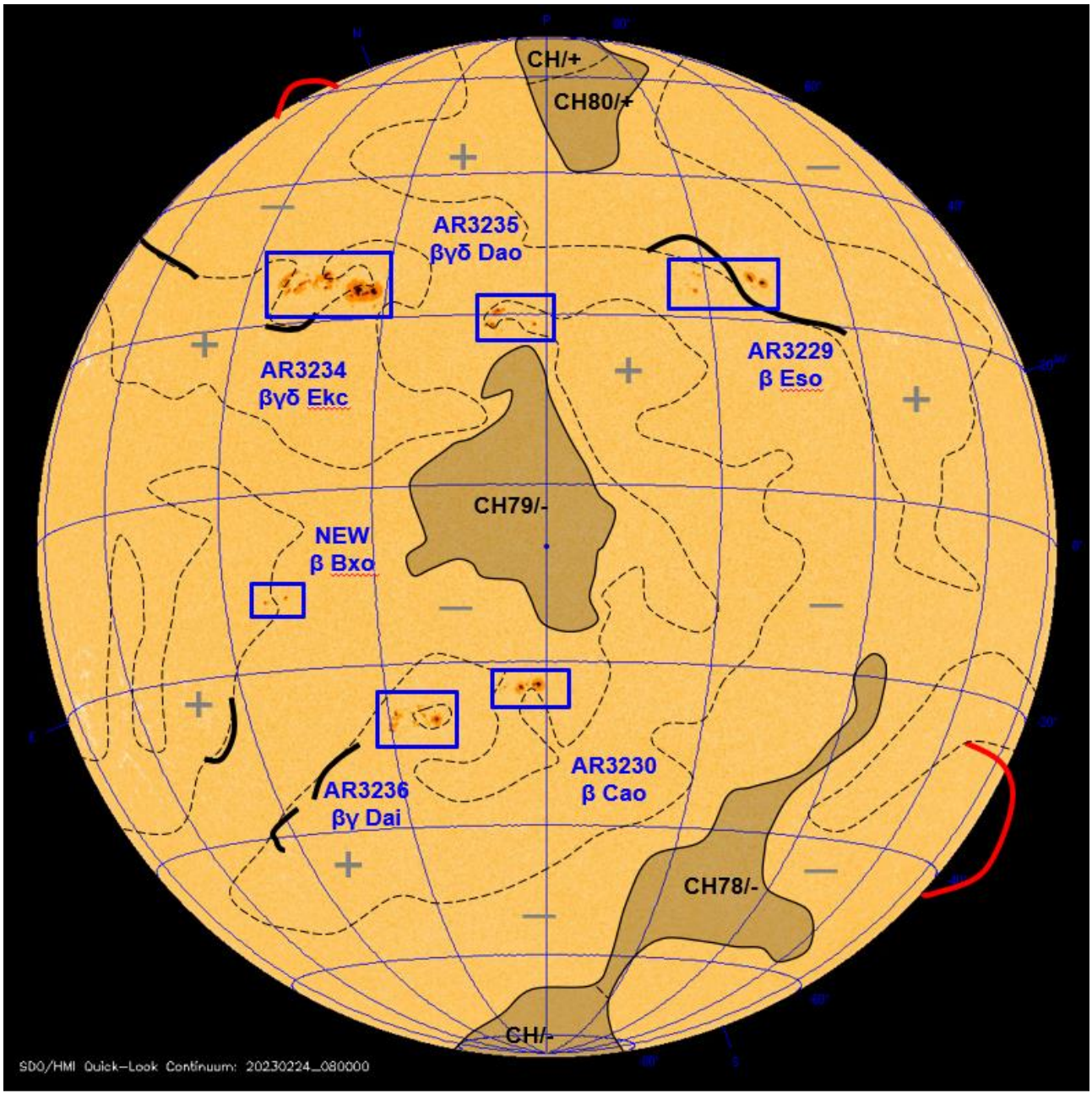
likely HSS from CH79.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is most likely to remain at background levels, but with a slight chance of reaching the S1 level. High energy (greater than 2 MeV) electron flux is likely to reach Moderate, perhaps High levels at the diurnal maxima. The associated 24-hour fluence is likely to remain below the Active threshold (1e8 integrated pfu) but with a possible erratic rising trend, although confidence is currently low.

Figure 1. Solar Analysis Valid 24/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A glancing blow from a CME is possible on 25 Feb, which left the Sun from the northwest on 21 Feb, but most of this should pass above Earth and confidence is low.

Earth is currently experiencing a HSS with elevated or slightly elevated wind speeds. This appears to be transitioning between CH77/+, and CH78/- with variations in the phi angle. CH78 is a non-persistent feature the bulk of which is well south on the disc, which has made judging the timing of the arrival of the HSS difficult. It does appear likely that it is starting to have some influence, however. The leading edge of a further coronal hole, CH79/-, is just west of centre disc and straddles the solar equator. This was present on the previous rotation but is larger this time around, perhaps with the leading edge a little further ahead. This arrived early on the equivalent of Day 4 (27 Feb) last time around and could be a little earlier on this rotation with the leading edge being a little ahead. Overall, it seems likely that wind speeds will be elevated or slightly elevated for much of this period, perhaps increasing to strong by Day 4. Both coronal holes have negative polarity, and therefore are more favoured for a geomagnetic response now we are approaching the March equinox.

Geomagnetic activity is expected to be Quiet to Active with a risk of G1/Minor Storms due to the various HSS influences. This risk is probably highest on Days 3 and 4 (26-27 Feb) due to the likely HSS from CH79.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	10	30	30
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
*	*	*	*	*	*	*

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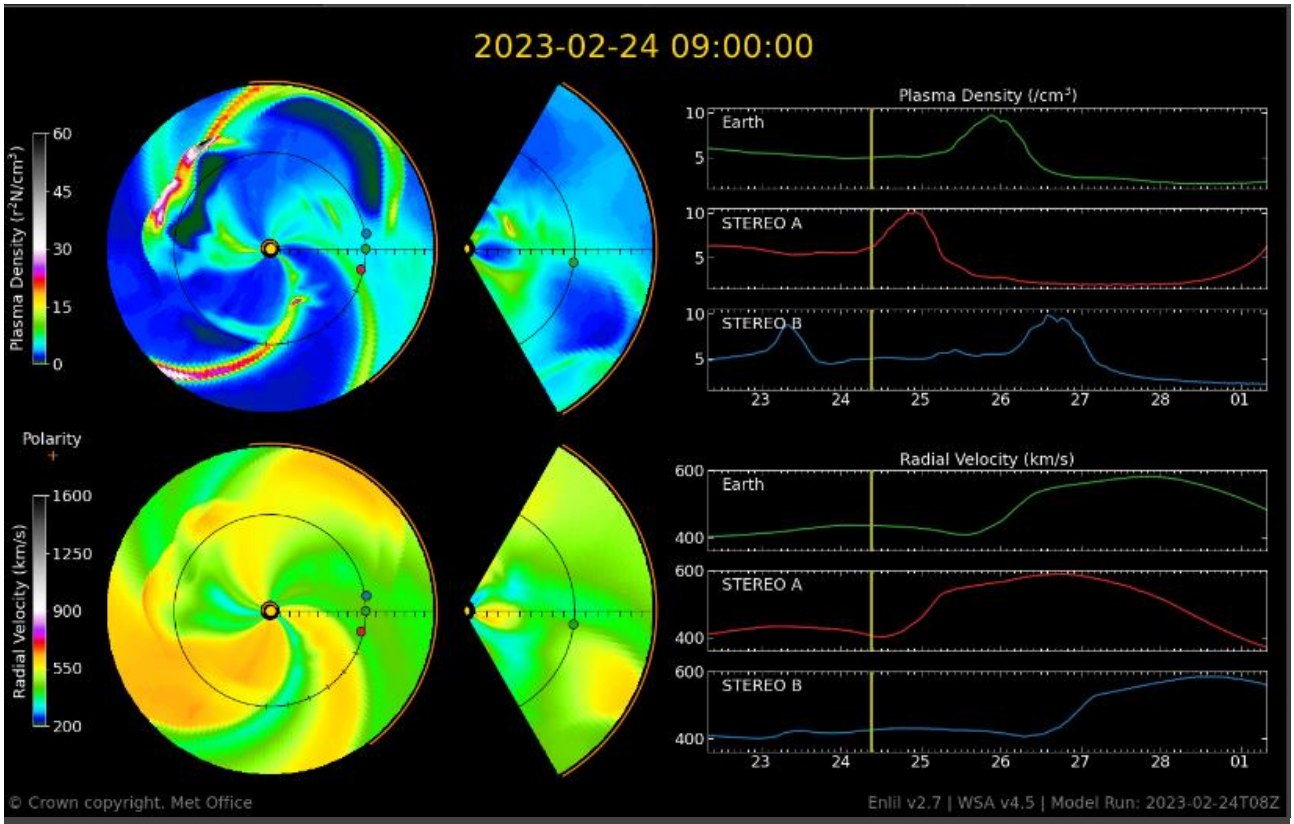
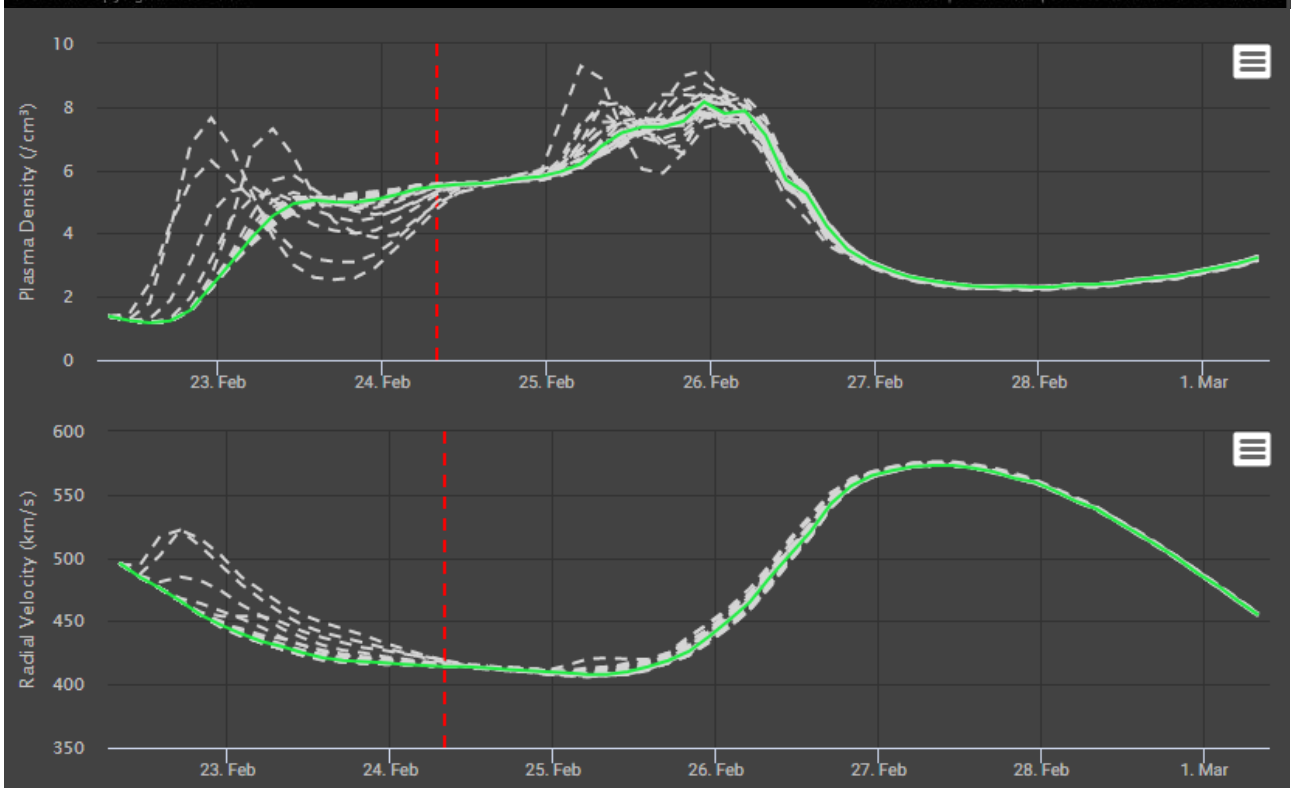
Figure 2: MOSWOC Enlil and ensemble showing the very slight risk of a CME glancing blow on Day 2 (25 Feb). Enlil is currently under-estimating wind speeds somewhat, with speeds likely to remain slightly higher than suggested by Enlil until the HSS arrives from CH79 on Day 3 (26 Feb), which seems well captured by Enlil at this stage.





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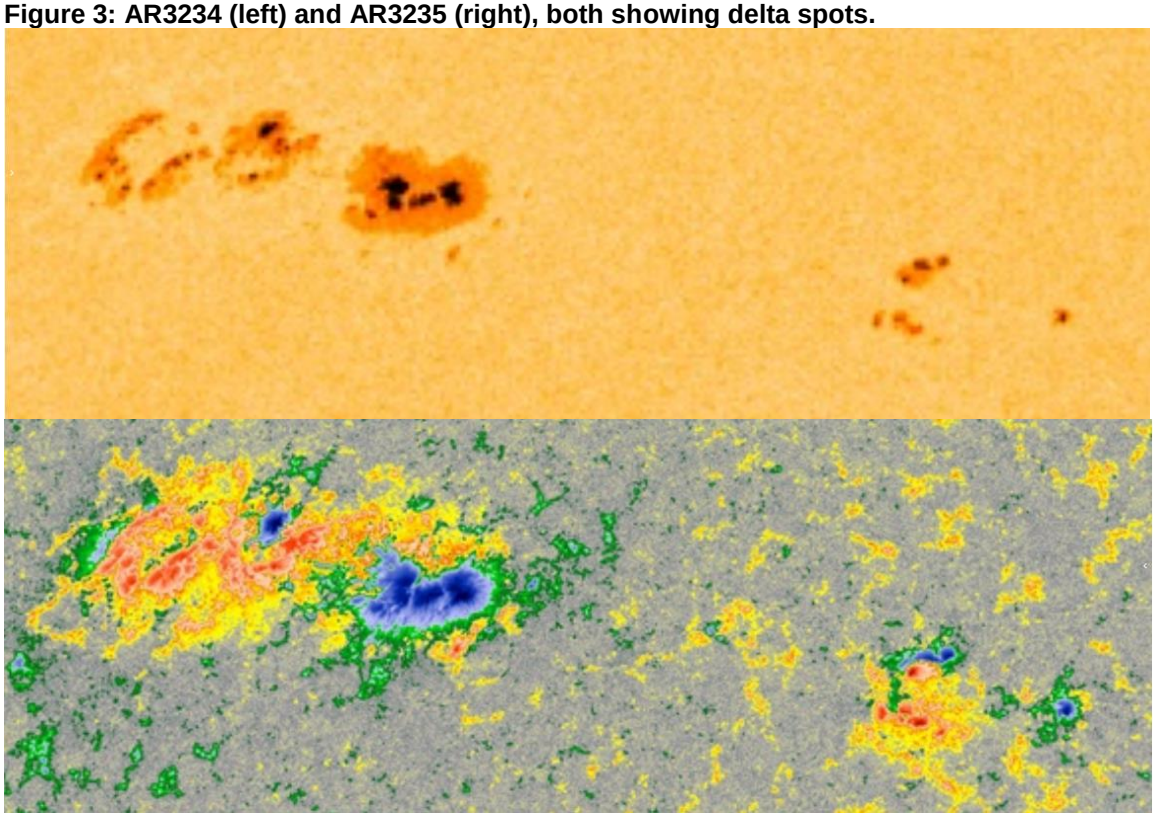
Radio Blackouts - X-Ray Flares:
There are six sunspot regions on the visible disc. AR3234 (Ekc/Beta-Gamma-Delta) remains the largest and probably the most significant region, with a gamma configuration and a delta region in one of the intermediate spots. AR3235 (Dao/Beta-Gamma-Delta) remains small in area, but has become complex with a small delta spot developing. It also has a north-south magnetic alignment which increases magnetic shear. AR3236 (Dai/Beta) has developed rapidly in the last 24 hours. AR3229 and AR3230 have both been fading slightly. Another new region has emerged in the southeast quadrant, but is currently small, magnetically simple and weak.

Solar activity is Low with occasional C-class flares in the last 24 hours, however further M-class flares are likely. There remains a slight chance of High solar activity from any isolated X-class flares.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	60	60	60	60
Very Active	R3 to R5 X Class	No	15	15	15	15

Figure 3: AR3234 (left) and AR3235 (right), both showing delta spots.



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Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at Background levels. There remains a slight chance of an S1 or higher event, should any larger flares occur. The probabilities remains steady through the period as no significant regions are due to rotate off the disc in this period.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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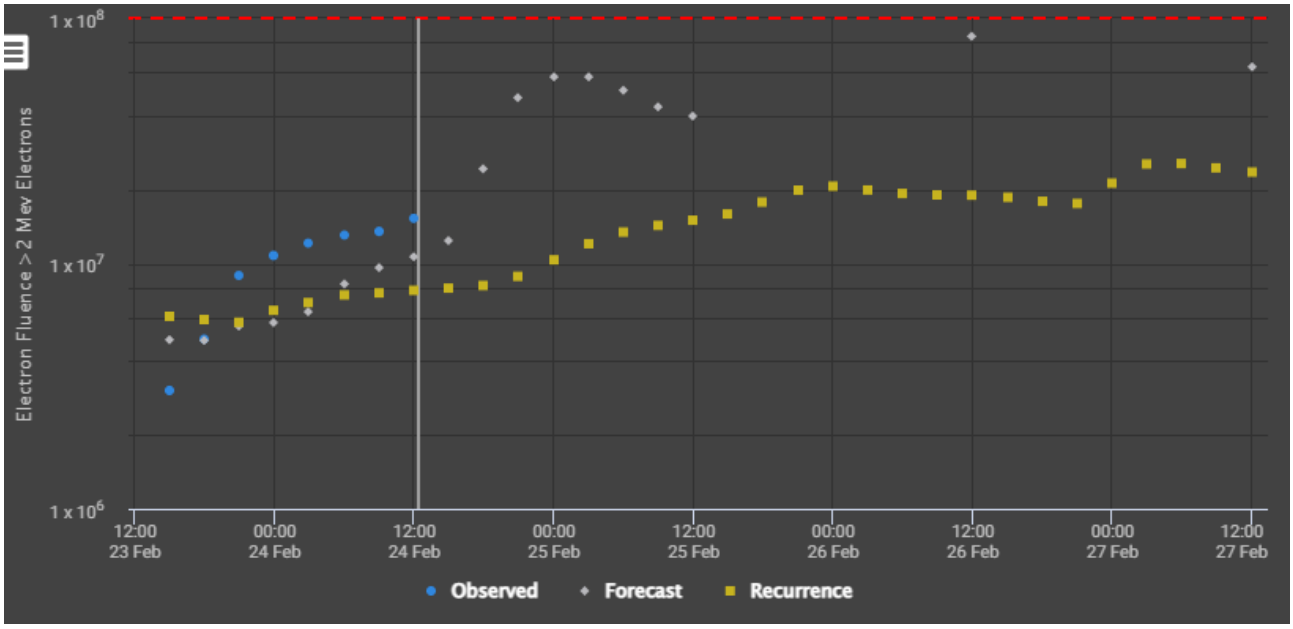
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) observed at GOES16 is at mostly background to moderate levels due to the influence of CH77. Further HSS influence is likely through much of this period, perhaps with a more significant HSS from CH79 arriving on Day 3 (26 Feb). Electron charging is likely to occur from the various faster winds, however any geomagnetic activity may temporarily suppress flux levels. In addition, faster wind speeds at times, especially later in the period, may compress the radiation belt inside GEO with GOES16 perhaps not measuring the most charged part of the belt. As a consequence, confidence is low in this forecast.

The associated 24-hour fluence is likely to show an erratic rising trend. There is a possibility of exceeding the Active (1e8 integrated pfu) threshold through this period, but with a more significant response becoming more likely after the end of this period. MOSWOC REFM is suggesting a rise to near Active, which is probably reasonable, although with significant uncertainty in the timing and intensity of any further rise.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	20	30	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: MOSWOC REFM showing a rise to near Active (1e8 integrated pfu). A rise is reasonable, although the timing and intensity of the rise is low confidence.



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